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UK CL (Edition R) H1Q QHC QHX QJC QKA QKN
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(54) Abstract Title
**Multi-band antenna and switch system**

(57) Antenna 260 comprising a flexible dielectric sheet 264 imprinted with a conductive pattern 262 where the flexible dielectric sheet may be wrapped around a rigid core. The antenna may comprise more than one pattern each including at least two leads 266,268 and may have electronic components 278,276 attached to the dielectric. By coupling a transceiver to a different pairs of leads, corresponding to different patterns, the antenna may be operative to a plurality of RF modes. The antenna may have a switch coupled between one of the leads and the ground where the corresponding lead of the pattern is connected to a multi mode transceiver. The switch may comprise a frequency dependent impedance unit. A frequency dependent antenna switch system coupled between an antenna and the ground where the switch is at an open mode at a first frequency and a closed mode at a second frequency. Antenna switch system comprising a first phase shift unit coupled between a first end of an antenna and a first transceiver and a second phase shift unit coupled between a second end of the antenna and a second transceiver. Method for operating a dual section transceiver and an antenna where the antenna is coupled to the ground via a variable impedance connection and each of the transceiver sections is associated with frequency band. The variable impedance connection is set to a high value when the selected frequency band is low and vice versa. The transceivers may be connected to the antenna via a phase shift connection.

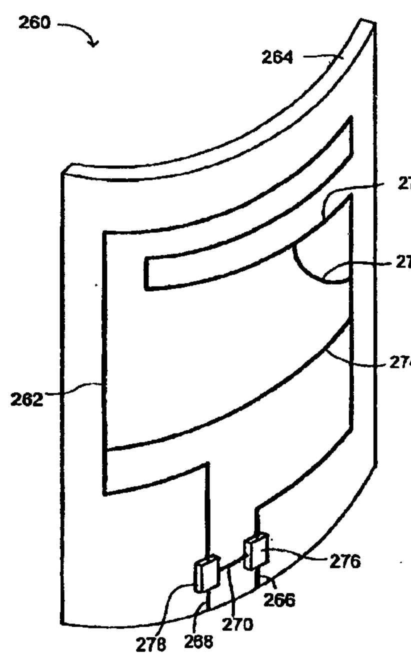



FIG. 7B

GB 2 361 584 A

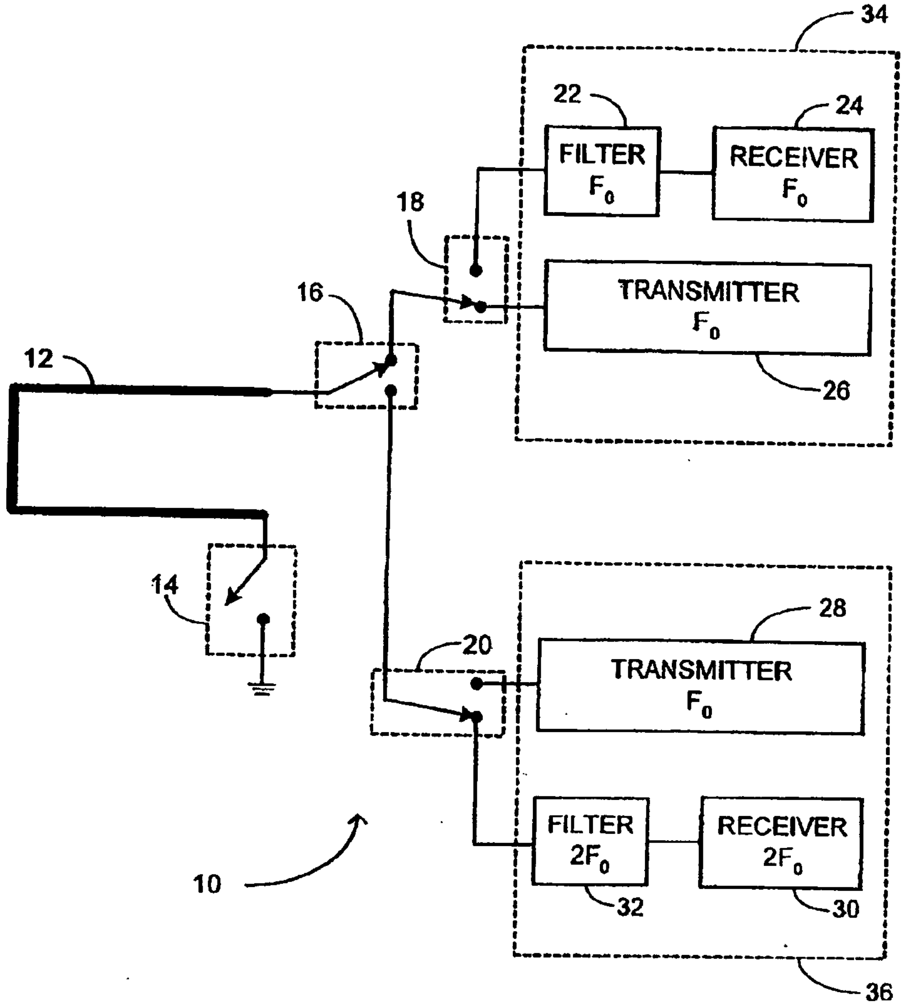
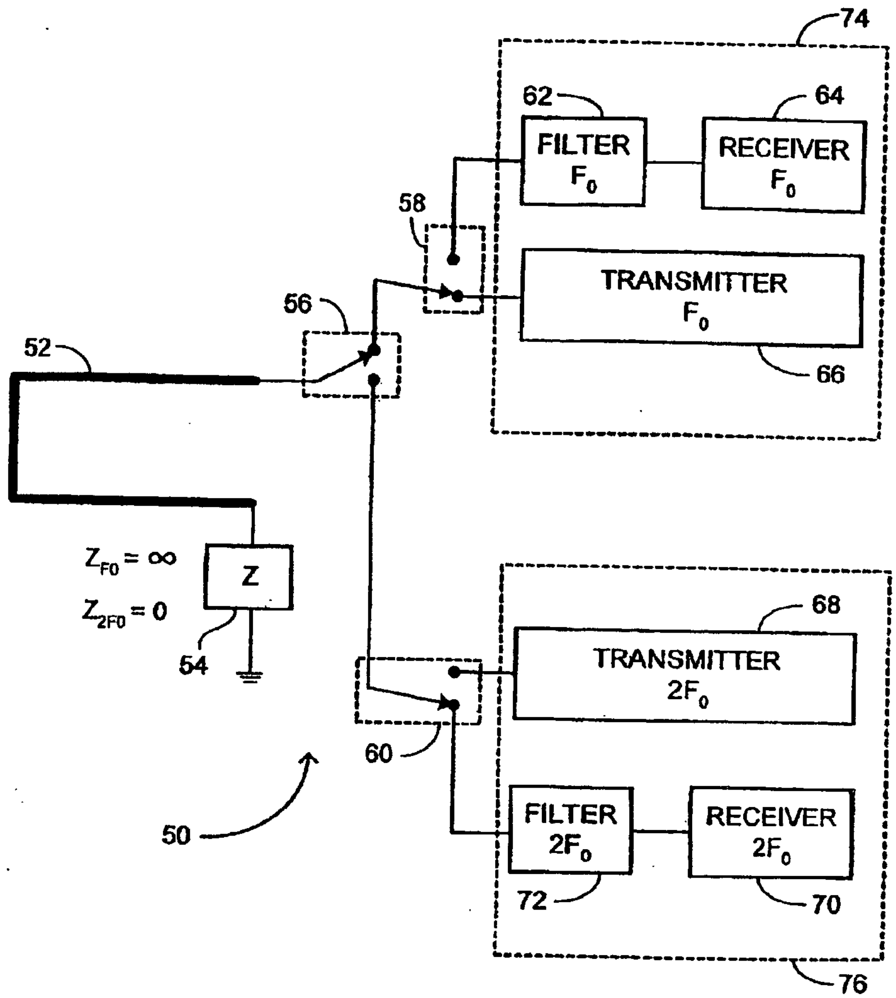

34
22
FILTER
$F_0$
24
RECEIVER
$F_0$
18
TRANSMITTER
$F_0$
16
12
26
14
28
20
TRANSMITTER
$F_0$
FILTER
$2F_0$
RECEIVER
$2F_0$
10
32
30
36

FIG. 1

2/11



74
62
64
FILTER
$F_0$
RECEIVER
$F_0$
58
TRANSMITTER
$F_0$
56
52
66
$Z_{F0} = \infty$
Z
$Z_{2F0} = 0$
54
68
TRANSMITTER
$2F_0$
60
FILTER
$2F_0$
RECEIVER
$2F_0$
50
72
70
76


FIG. 2

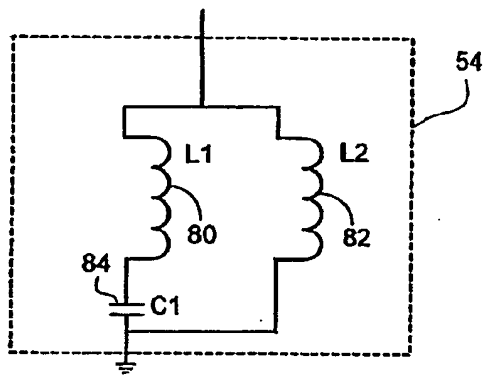



FIG. 3

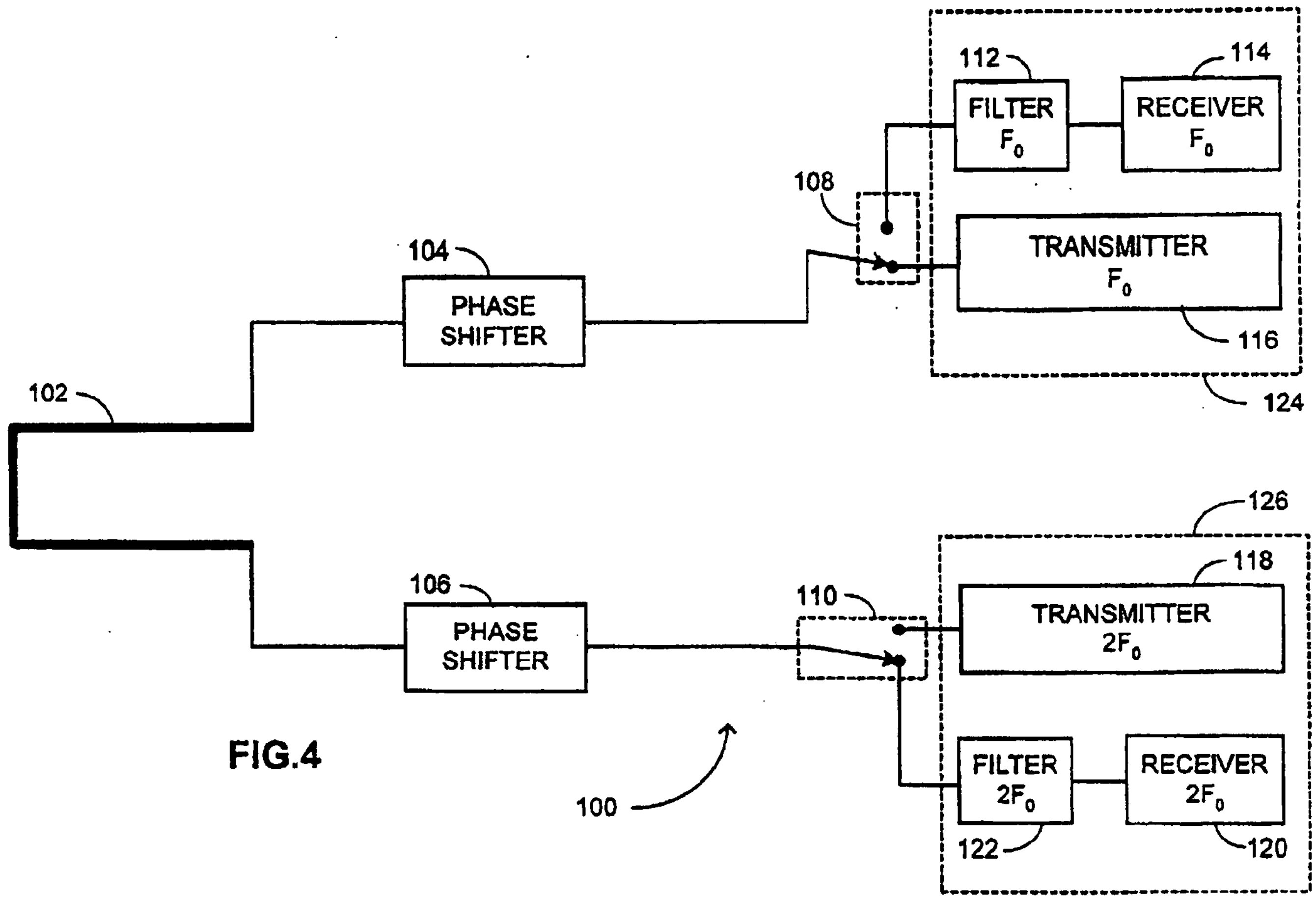

102
104
PHASE SHIFTER
106
PHASE SHIFTER
108
110
112
FILTER $F_0$
114
RECEIVER $F_0$
TRANSMITTER $F_0$
116
124
126
118
TRANSMITTER $2F_0$
FILTER $2F_0$
RECEIVER $2F_0$
122
120
100

FIG.4

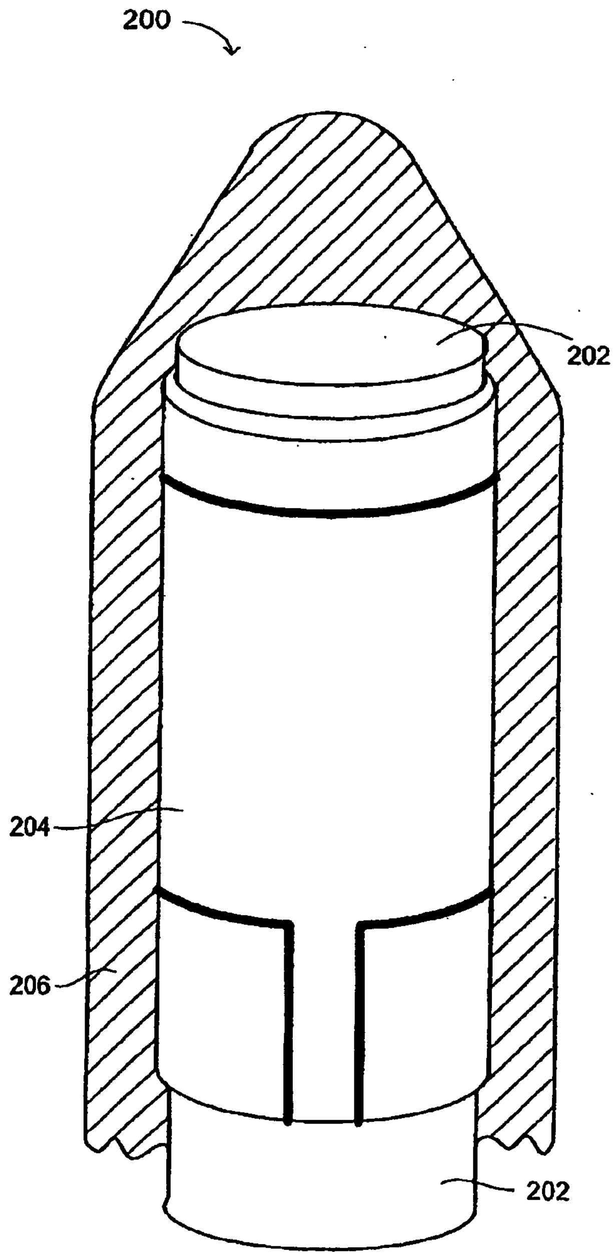



FIG. 5

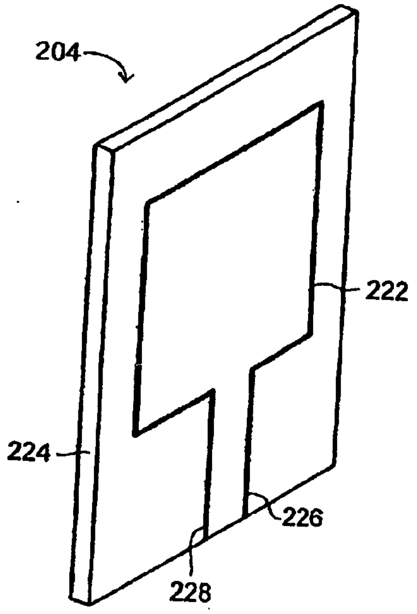



FIG. 6

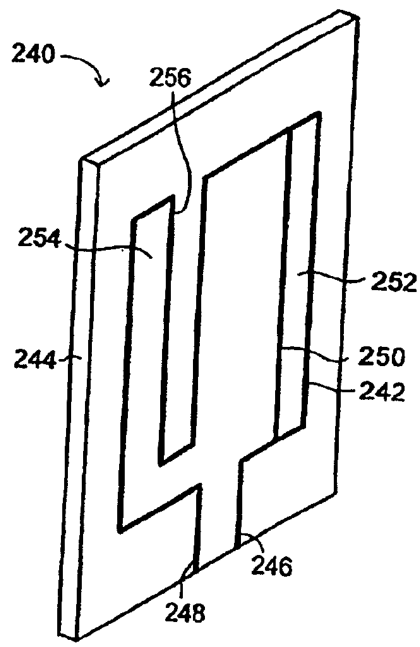



FIG. 7A

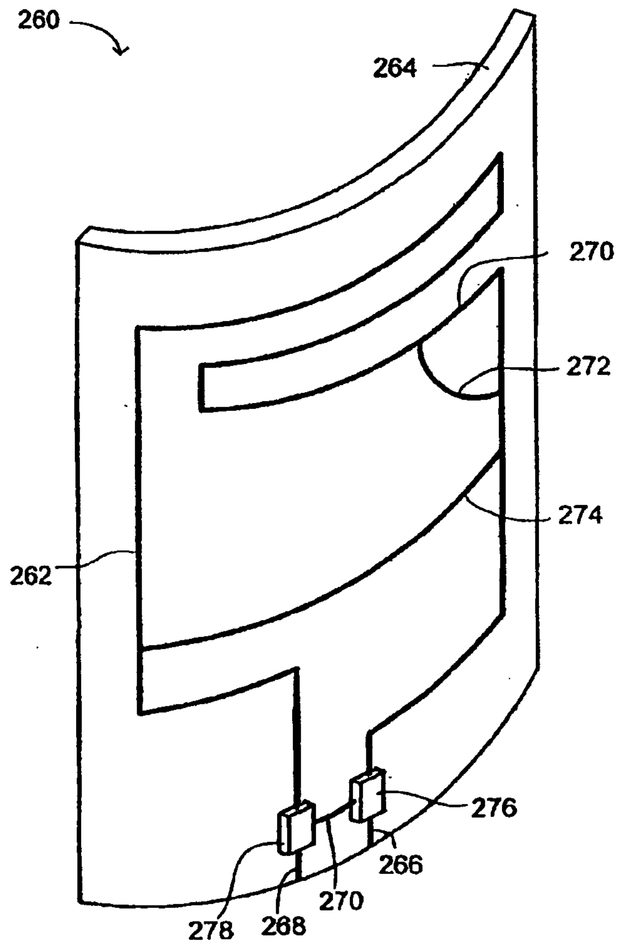



FIG. 7B

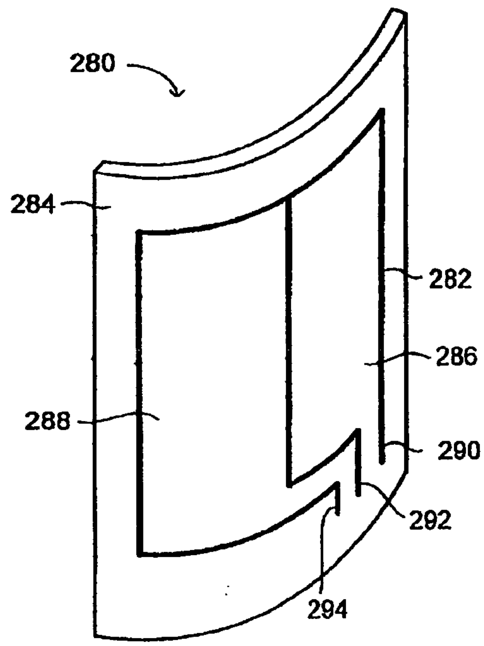



FIG. 8A

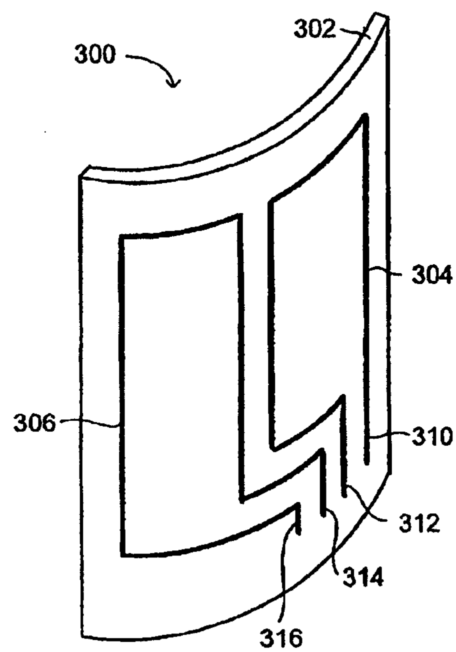



FIG. 8B

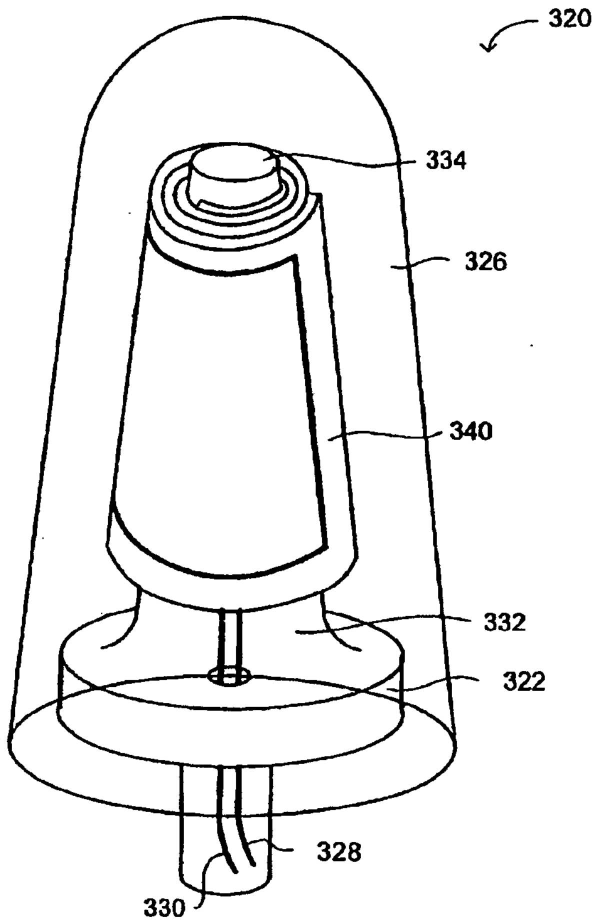



FIG. 9A

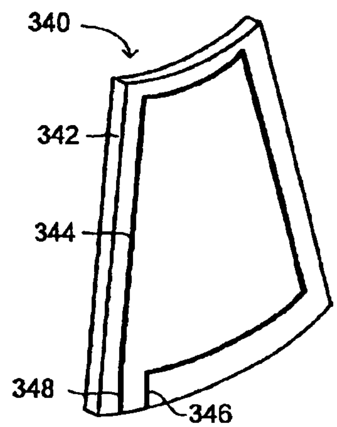



FIG. 9B

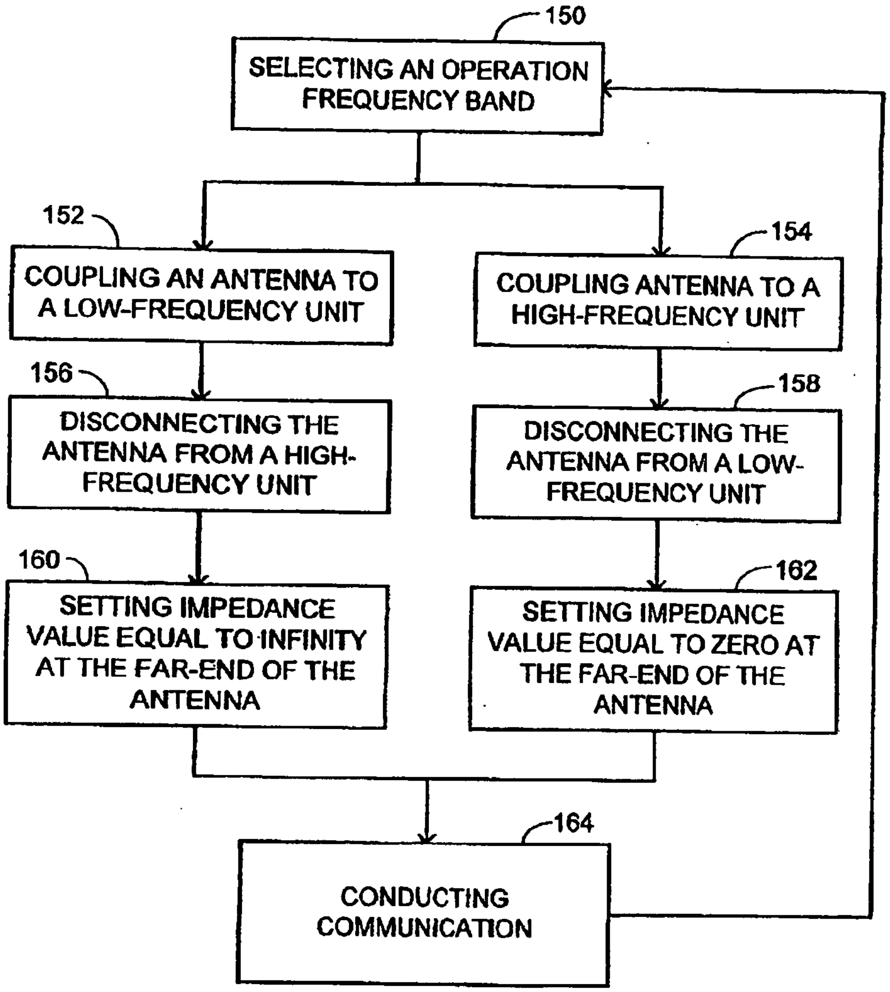

150
SELECTING AN OPERATION FREQUENCY BAND
152
COUPLING AN ANTENNA TO A LOW-FREQUENCY UNIT
154
COUPLING ANTENNA TO A HIGH-FREQUENCY UNIT
156
DISCONNECTING THE ANTENNA FROM A HIGH-FREQUENCY UNIT
158
DISCONNECTING THE ANTENNA FROM A LOW-FREQUENCY UNIT
160
SETTING IMPEDANCE VALUE EQUAL TO INFINITY AT THE FAR-END OF THE ANTENNA
162
SETTING IMPEDANCE VALUE EQUAL TO ZERO AT THE FAR-END OF THE ANTENNA
164
CONDUCTING COMMUNICATION

FIG. 10

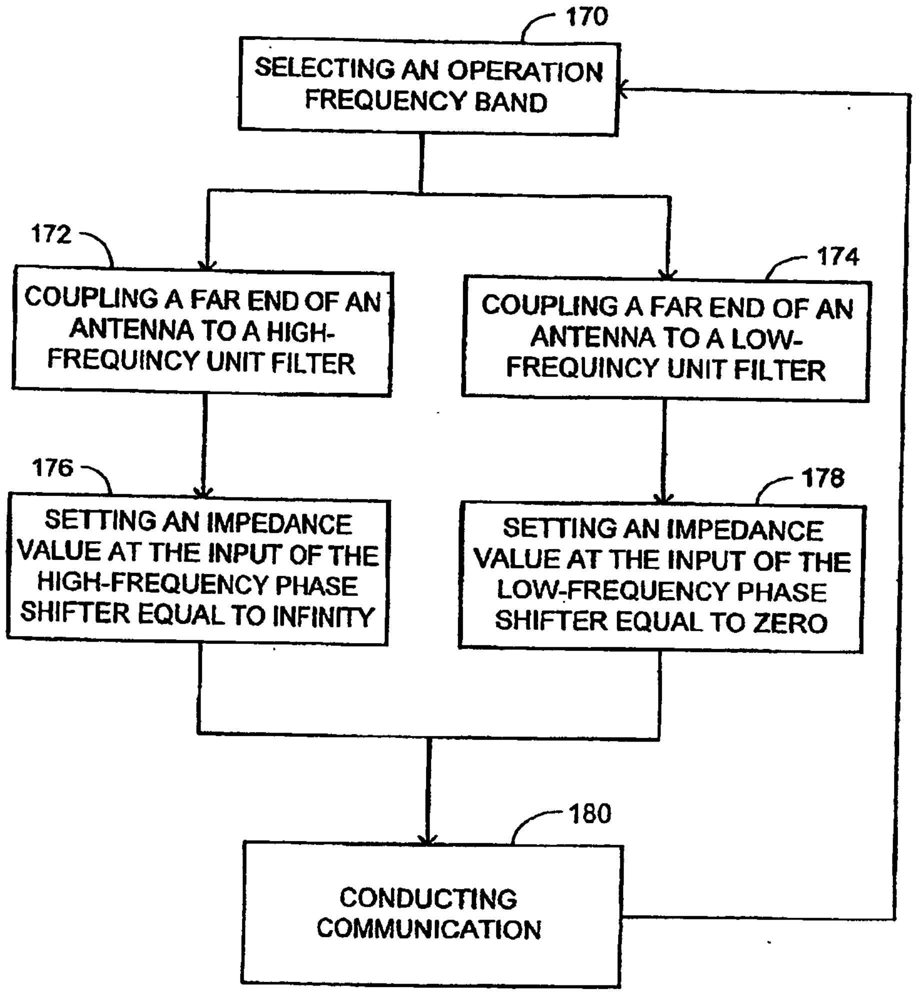

170
SELECTING AN OPERATION FREQUENCY BAND
172
COUPLING A FAR END OF AN ANTENNA TO A HIGH-FREQUINCY UNIT FILTER
174
COUPLING A FAR END OF AN ANTENNA TO A LOW-FREQUINCY UNIT FILTER
176
SETTING AN IMPEDANCE VALUE AT THE INPUT OF THE HIGH-FREQUENCY PHASE SHIFTER EQUAL TO INFINITY
178
SETTING AN IMPEDANCE VALUE AT THE INPUT OF THE LOW-FREQUENCY PHASE SHIFTER EQUAL TO ZERO
180
CONDUCTING COMMUNICATION

FIG. 11

2361584

# MULTI-BAND TRANSCEIVER

## FIELD OF THE INVENTION

The present invention relates to multi-band antennae in general, and to multi-band antenna systems for mobile communications devices, in particular.

## BACKGROUND OF THE INVENTION

Wireless communication is often required to operate in more than one frequency range. For example, in different parts of the world, cellular telephone systems use different operating frequency ranges. Among the digital cellular telephone systems, the operating frequencies of the GSM (Global System for Mobile Telecommunications) system are in the 890-960 MHz band, those of JDC (Japanese Digital Cellular) 800 and 1500 MHz band. The operating frequencies of the PCN (Personal Communication Network) are in the 1710-1880 MHz band and those of the PCS (Personal Communication System) in the 1850-1990 MHz band. The operating frequencies of the American AMPS mobile telephone system

are 824-894 MHz and the operating frequencies of the DECT (Digital European Cordless Telephone) system are 1880-1900 MHz.

In the mobile telephones designed for these systems, simple cylindrical coil or helical antennae or whip antennae are usually used. The resonant frequency of an antenna is determined by its electrical length, which should be a specific part of the wavelength of the radio frequency used.

The electrical length of a helical antenna used at mobile telephone frequencies is typically $3\lambda/8$, $5\lambda/8$ or $\lambda/4$., where $\lambda$ is the wavelength in use. Similarly, the electrical length of a whip antenna is typically $\lambda/2$, $5\lambda/8$, $3\lambda/8$ or $\lambda/4$. Solutions are also known where the whip or helical element may be connected in turn to the antenna port of the radio set. Another approach is whip-helix series connections, which may be pushed partially inside the telephone.

Since the resonant frequency of the antenna according to the prior art is, as has been shown, related to the length of the antenna via the wavelength, it is only possible to use a certain antenna in a mobile telephone that is designed for a cellular telephone system with a single frequency range. In some cases, however, one may wish to use the same telephone in some second frequency range. Then an effective antenna solution is required in addition to the appropriate RF components.

Known solutions for multi-band systems incorporate separate antennae, each specifically designed for operation over a predetermined range of frequencies. Unfortunately, the use of separate antennae would increase the cost, size and complexity of the portable phone, especially if additional space must be allocated for retraction of each antenna.

It is desirable therefore to provide a single compact multi-band antenna for operating in portable communications devices.

## SUMMARY OF THE PRESENT INVENTION

It is an object of the present invention to provide a novel method and system for conducting multi-band communication, which overcomes the disadvantages of the prior art.

In accordance with the present invention, there is thus provided an antenna, which includes a flexible dielectric sheet, and at least one conductive pattern, which is imprinted onto the flexible dielectric sheet.

In accordance with the present invention, there is also provided a frequency dependent antenna switch system for controlling the operation of an antenna. The antenna is coupled to a multi band transceiver. The switch system includes a switch, coupled between an antenna and the ground. The frequency dependent antenna switch is set to an open mode at a first frequency, respective of a first band of the multi band transceiver, and is set to a closed open mode at a second frequency, respective of a second band of the multi band transceiver.

In accordance with the present invention, there is further provided an antenna switching system which includes a first phase shift unit, and a second phase shift unit, coupled between a second end of said antenna and a second transceiver. The first phase shift unit is coupled between a first end of an antenna and a first transceiver. The second phase shift unit is coupled between a second end of the antenna and a second transceiver.

In accordance with the present invention, there is further provided a method for operating a dual section transceiver and an antenna, coupled there between. The antenna is further coupled to the ground via a variable impedance connection. Each of the transceiver sections is associated with a respective frequency band. Each of the transceiver sections includes at least one of a transmitter and a receiver. The method includes the steps of:

coupling the antenna to the transceiver section associated with a selected one of the frequency bands,

disconnecting the antenna from the transceiver section associated with the non selected frequency band,

setting the variable impedance connection to a high impedance value, when the selected frequency band is low, and

setting the variable impedance connection to a low impedance value, when the selected frequency band is high.

In accordance with the present invention, there is also provided a method for operating two transceivers and an antenna. One of the transceivers is a low band transceiver and the other is a high band transceiver. The low band transceiver is coupled to a first end of the antenna via a first phase shift connection. The high band transceiver is coupled to a second end of the antenna via a second phase shift

connection. Each of the transceiver sections includes a transmitter and a receiver. The method includes the steps of:

coupling the antenna to the receiver of a non selected one of the transceivers,

setting the first phase shift connection to a predetermined value thereby inducing low impedance from the low band transceiver to the antenna, when selecting the high band transceiver, and

setting the second phase shift connection to a predetermined value thereby inducing high impedance from the high band transceiver to the antenna, when selecting the low band transceiver.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Figure 1 is a schematic illustration of a communication multi-band system, constructed and operative in accordance with a preferred embodiment of the present invention;

Figure 2 is a schematic illustration of a communication multi-band system, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 3 is an illustration in detail of an alternative realization of the impedance unit, of the multi-band system of Figure 2;

Figure 4 is a schematic illustration of a communication multi-band system, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 5 is a schematic illustration of an antenna unit, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 6 is a schematic illustration of an antenna element of Figure 5;

Figure 7A is a schematic illustration of an antenna element, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 7B is a schematic illustration of an antenna element, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 8A is a schematic illustration of an antenna element, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 8B is a schematic illustration of an antenna element, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 9A is a schematic illustration of an antenna unit, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 9B is an illustration in perspective of the antenna element of Figure 9A, in an unfolded position;

Figure 10 is a schematic illustration of a method for operating the communication multi-band system of Figure 1, operative in accordance with a further preferred embodiment of the present invention; and

Figure 11 is a schematic illustration of a method for operating the communication multi-band system of Figure 4, operative in accordance with another preferred embodiment of the present invention.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present mitigates the disadvantages of the prior art by providing a novel antenna system, which can operate in more than one mode.

Reference is now made to Figure 1, which is a schematic illustration of a communication multi-band system, generally referenced 10, constructed and operative in accordance with a preferred embodiment of the present invention. System 10 includes a multi-band antenna 12, four switches 14, 16, 18 and 20, two filters 22 and 32, two receivers 24 and 30, and two transmitters 26 and 28. Transmitter 26, filter 22 and receiver 24 represent a low-frequency unit 34. Transmitter 28, filter 32 and receiver 30 represent a high-frequency unit 36.

Antenna 12 is coupled to switches 14 and 16. Switch 18 is coupled to switch 16, filter 22 and to transmitter 26. Switch 20 is coupled to switch 16, filter 32 and to transmitter 28. Receiver 24 is coupled to filter 22. Receiver 30 is coupled to filter 32.

System 10 can operate in low-frequency mode as well as in high frequency mode. Low-frequency mode can correspond to GSM systems (800 MHz), and high-frequency mode can correspond PCN or PCS systems, working at frequencies 1800 MHz and 1900 MHz respectively. Typically, the high frequency and low frequency are harmonically related. In the preferred embodiment of the present invention, the high frequency

is approximately twice as high as the low frequency. System 10 can further operate either in a transmit mode or in a receive mode. The illustration presented in Figure 1 corresponds to low frequency transmit mode.

When system 10 operates in the low frequency mode, antenna 12 constitutes a quarter wavelength monopole. Different designs can be used to implement this type of antenna. It can be made of a single wire, or it can be printed onto corresponding dielectric substrate or the like. The length of antenna 12 is equal to one quarter of a wavelength, which corresponds to the center of the low-frequency signal spectrum. The detailed description of the preferred design of antenna 12 is presented hereinbelow.

In the low frequency mode, switch 14 is opened, so that the far end of antenna 12 is free, and switch 16 connects the other end of antenna 12 to switch 18. In transmit mode (as shown in Figure 1), antenna 12 is coupled to transmitter 26 (via switches 16 and 18). In low frequency receive mode antenna 12 is coupled to filter 22.

When the system works in the high-frequency mode, switch 14 is closed and switch 16 couples antenna 12 to switch 20. In this case antenna 12 forms a half wavelength loop. In the high frequency transmit mode antenna 12 is coupled to transmitter 28 (via switches 16 and 20), and in the receive mode antenna 12 is coupled to filter 32. Hence, system

10 can operate in more than one band using a single antenna, by employing a special antenna design and unique switching.

Reference is now made to Figure 2, which is a schematic illustration of a communication multi-band system, generally referenced 50, constructed and operative in accordance with a further preferred embodiment of the present invention.

System 50 includes a multi-band antenna 52, an impedance unit 54, three switches 56, 58 and 60, two filters 62 and 72, two receivers 64 and 70, and two transmitters 66 and 68. Transmitter 66, filter 62 and receiver 64 represent a low-frequency unit 74. Transmitter 68, filter 72 and receiver 70 represent a high-frequency unit 76.

Antenna 52 is coupled to impedance unit 54 and to switch 56. Switch 58 is coupled to switch 56, filter 62 and to transmitter 66. Switch 60 is coupled to switch 56, filter 72 and to transmitter 68. Receiver 64 is coupled to filter 62. Receiver 70 is coupled to filter 72.

System 50 can operate in low-frequency mode and in high frequency mode. Typically, the high frequency and low frequency are harmonically related, and in this embodiment the high frequency is approximately twice as high as the low frequency. System 50 further can operate in transmit mode or in receive mode. The illustration presented in Figure 2, corresponds to low frequency transmit mode.

System 50 is generally similar to system 10 of Figure 1, with the difference of having impedance unit 54 replacing switch 14. Impedance unit 54 represents complex impedance Z, which is a function of the frequency. Impedance unit 54 is designed in such a way, that the impedance value is equal to infinity at the low frequency $F_0$ and equal to zero at the high frequency $2F_0$. Impedance unit 54 can be constructed as a shorted quarter-wavelength transmission line for the low frequency $F_0$. The quarter-wavelength transmission lines transform the impedance, from a short circuit to an open circuit (as required for quarter wavelength monopole antenna). For the high frequency $2F_0$, the same transmission line will be half-wavelength long. In this case there is no impedance transformation, hence the impedance value is equal to zero (as required for half wavelength loop).

Reference is now made to Figure 3, which is an illustration in detail of an alternative realization of impedance unit 54. The circuitry shown in Figure 3 includes two inductors 80 (L1) and 82 (L2) and a capacitor 84 (C1). Capacitor 84 and inductor 80 are connected in series there between, and inductor 82 is connected in parallel to both of them. The values of L1, L2 and C1 are selected in such a way, that L1 and C1 possess series resonant at the frequency $2F_0$, and L2 is in parallel resonance with L1 and C1 at the frequency $F_0$. In the case of the series resonance $Z=0$, and in the case of the parallel resonance $Z=\infty$.

Referring back to Figure 2, when system 50 operates in the low frequency mode, antenna 52 constitutes a quarter wavelength monopole. Different designs can be used to implement this type of antenna. It can be made of a single wire, or it can be printed onto respective dielectric substrate or the like.

According to the above mentioned, in the low frequency mode, $Z_{F0}=\infty$, so that the far end of antenna 52 is free, and switch 56 connects the other end of antenna 52 to switch 58. In the transmit mode (as shown in Figure 2), antenna 52 is coupled to transmitter 66 (via switches 56 and 58). In receive mode antenna 52 is coupled to filter 62.

When the system 50 operates in high-frequency mode impedance $Z_{2F0}$ is equal to zero, and switch 56 couples antenna 52 to switch 60. In this case antenna 52 forms a half wavelength loop. In transmit mode antenna 52 is coupled to transmitter 68 (via switches 56 and 60), and in the receive mode antenna 52 is coupled to filter 72.

Reference is now made to Figure 4, which is a schematic illustration of a communication multi-band system, generally referenced 100, constructed and operative in accordance with a further preferred embodiment of the present invention.

System 100 includes a multi-band antenna 102, two phase shifters 104 and 106, two switches 108 and 110, two filters 112 and 122, two receivers 114 and 120, and two transmitters 116 and 118. Transmitter

116, filter 112 and receiver 114 represent a low-frequency unit 124. Transmitter 118, filter 122 and receiver 120 represent a high-frequency unit 126.

Phase shifter 104 is coupled to the first end of antenna 102 and to switch 108. Phase shifter 106 is coupled to the second end of antenna 102 and to switch 110. Switch 108 is coupled to filter 112 and transmitter 116. Switch 110 is coupled to filter 122 and transmitter 118. Receiver 114 is coupled to filter 112. Receiver 120 is coupled to filter 122.

System 100 can operate in low-frequency mode and in high frequency mode. Typically, the high frequency and low frequency are harmonically related. In this embodiment the high frequency is approximately twice as high as the low frequency. System 100 can further operate in the transmit mode or in receive mode. The illustration presented in Figure 4 corresponds to low frequency transmit mode. When system 100 operates in low-frequency mode, then switch 110 is coupled to filter 122. When system 100 operates in high-frequency mode, then switch 108 is coupled to filter 112.

For the low-frequency mode the impedance value at the input of phase shifter 106 (which is coupled to antenna 102) must be set equal to infinity. For the opposite case of the high-frequency mode, the impedance value at the input of phase shifter 104 (which is coupled to antenna 102) must be set equal to zero. This is achieved by a special design of phase

shifters 104 and 106. Any conventional type of phase shifters can be used, such as transmission lines of corresponding length, for example. This approach advantageously allows to exclude units such as the band switch 14 from the design of system 10 or impedance unit 54 from the design of system 50.

Reference is now made to Figure 5, which is a schematic illustration of an antenna unit, generally referenced 200, constructed and operative in accordance with a further preferred embodiment of the present invention. Antenna unit 200 includes a core 202, a flexible antenna element 204 and coating portion 206. Core 202 is made of a material which is generally more rigid than the materials from which flexible antenna element 204 and coating portion 206 are made of, so as to support the structure of antenna unit 200. Flexible antenna element 204 is wrapped around core 202. Coating portion 206 covers the structure formed by core 202 and flexible antenna element 204. It is noted that coating portion 206 can be made of elastic materials, which are injected molded around the structure formed by core 202 and flexible antenna element 204.

Reference is now made to Figure 6, which is a schematic illustration of an antenna element 204 of Figure 5. Antenna element 204 includes a flexible dielectric sheet 224 and conducting pattern 222, which is printed onto flexible dielectric sheet 224. It is noted that the term

"printed" includes any form of attaching a conductive pattern to a dielectric sheet, such as adhesive attaching, joining by means of heating, pressing together, chemically forming thereon (where the flexible sheet was previously covered with a conductive sheet), painting with conductive ink, and the like.

Conducting pattern 222 includes two connection leads 226 and 228, for connecting it to a transceiver (not shown). It is noted that this structure provides structural accuracy, which significantly increases the ability to customize the electromagnetic design. Conventional antenna units, made of wire, which is wrapped to the shape of a helix, provide single mode electromagnetic behavior. The structure presented in Figure 5, is multi mode operation. This structure is subject to modification at numerous options, as will be disclosed further below.

Reference is now made to Figure 7A, which is a schematic illustration of an antenna element, generally referenced 240, constructed and operative in accordance with a further preferred embodiment of the present invention. Antenna element 240 includes a flexible dielectric sheet 244 and conducting pattern 242, which is printed onto flexible dielectric sheet 244. Conducting pattern 242 includes two connection leads 246 and 248, for connecting it to a transceiver (not shown). Conducting pattern 242 includes two variations in comparison with conducting pattern 222 of

Figure 6. The first variation includes a jumper portion 250, which produces two conductive loops 252 and 254, each operative to resonate according to different parameters. The second variation includes a winding portion 256, which increases the length of a portion of conductive pattern 242, substantially providing an adjustable length antenna.

Reference is now made to Figure 7B, which is a schematic illustration of an antenna element, generally referenced 260, constructed and operative in accordance with another preferred embodiment of the present invention. Antenna element 260 includes a flexible dielectric sheet 264 and conducting pattern 262, which is printed onto flexible dielectric sheet 264. Antenna element 260 further includes two electronic components, 276 and 278. Conducting pattern 262 includes a horizontal jumper 274, a curved diagonal jumper 272 and a horizontal winding portion 270. Electronic components, 276 and 278 are each connected before leads 266 and 268, respectively. It is noted that electronic components, 276 and 278 can include any electrical component, such as a resistor, a capacitor, a coil, a resonator, an IC, and the like.

The ability to include electronic components in the structure of the antenna unit, even such as a power amplifier, greatly increases the efficiency of the entire system, reduces external and internal noise induction, and greatly improves the performance of the antenna unit.

Reference is now made to Figure 8A, which is a schematic illustration of an antenna element, generally referenced 280, constructed and operative in accordance with a further preferred embodiment of the present invention. Antenna element 280 includes a flexible dielectric sheet 284 and conducting pattern 282, which is printed onto flexible dielectric sheet 284. Conducting pattern 282 includes three leads 290, 292 and 294. Coupling a transceiver to any two of these leads provides a different mode, according to the length of the selected route and the option selected: quarter wavelength monopole or half wavelength loop. For example, connecting a transceiver to leads 290 and 292, operates a route which defines loop 286. Alternatively, connecting a transceiver to leads 292 and 294, operates a route which defines loop 288. A third option includes leads 290 and 294.

Reference is now made to Figure 8B, which is a schematic illustration of an antenna element, generally referenced 300, constructed and operative in accordance with another preferred embodiment of the present invention. Antenna element 300 includes a flexible dielectric sheet 302 and two conducting patterns 304 and 306, which are printed onto flexible dielectric sheet 302. Coupling a transceiver to either of conducting patterns 304 and 306, provides a different mode of operation. It is noted that more than two conducting patterns can be imprinted on flexible dielectric sheet 302.

Reference is now made to Figure 9A, which is a schematic illustration of an antenna unit, generally referenced 320, constructed and operative in accordance with a further preferred embodiment of the present invention. Antenna unit 320 includes a core 322, a flexible antenna element 340 and coating portion 326.

Core 322 is made of a material which is generally more rigid than the materials from which flexible antenna element 340 and coating portion 326 are made of, so as to support the structure of antenna unit 320. The general shape of core 322 is that of a cut cone, having a wide base 332 and a narrow top 334.

Reference is further made to Figure 9B, which is an illustration in perspective of antenna element 340 of Figure 9A, in an unfolded position. Flexible antenna element 340 has the general shape of a circular section. Flexible antenna element 340 is made of a flexible dielectric sheet 342 and a conductive pattern 344 imprinted thereon, and having two connector leads 346 and 348.

Referring back to Figure 9A, flexible antenna element 340 is wrapped around core 322. Coating portion 326 covers the structure formed by core 322 and flexible antenna element 340. It is noted that coating portion 326 can be made of elastic materials, which are injected molded around structure formed by core 322 and flexible antenna element 340. Antenna unit 320 can further include antenna connector wires 328

and 330, which are to be coupled between connector leads 346 and 348 and a transceiver (not shown).

Reference is now made to Figure 10, which is a schematic illustration of a method for operating the communication multi-band system of Figure 1, operative in accordance with a further preferred embodiment of the present invention. The following description is provided with respect to the antenna unit of Figure 1, while it is generally suitable for additional embodiments presented herein above.

In step 150 an operation frequency band is selected. With reference to Figure 1, system 10 receives information regarding active frequency band and selects a mode of operation. In the case of low-frequency mode of operation system 10 proceeds to step 152 and in the case of high-frequency mode of operation system 10 proceeds to step 154. It is noted that the selection of the active frequency band can be done manually, by a user.

In step 152, antenna 12 is coupled to low-frequency unit 34. With reference to Figure 1, switch 16 couples antenna 12 to low-frequency unit 34 via switch 18.

In step 156, antenna 12 is disconnected from high-frequency unit 36. With reference to Figure 1, switch 16 disconnects switch 20, and hence high-frequency unit 36, from antenna 12.

In step 160, an impedance value at the far end of antenna 12 is set equal to infinity. With reference to Figure 1, switch 14 is open. In this case the impedance value at the far end of antenna 12 is equal to infinity and antenna 12 represents a quarter wavelength monopole. The same results can be achieved by using a specified impedance unit instead of switch 14. With reference to Figures 2 and 3, impedance unit 54, having impedance Z, is connected between the far end of antenna 12 and the ground. As was described above, the value of the impedance Z at the low frequency $F_0$ is equal to infinity.

In step 164, system 10 conducts communication. With reference to Figure 1, system 10 conducts communication in the low-frequency band. Depending on operation mode, switch 18 couples either transmitter 26 or receiver 24 with antenna 12 via switch 16.

In step 154, antenna 12 is coupled to high-frequency unit 36. With reference to Figure 1, switch 16 couples antenna 12 to high-frequency unit 36 via switch 20.

In step 158, antenna 12 is disconnected from low-frequency unit 36. With reference to Figure 1, switch 16 disconnects switch18, and hence low-frequency unit 34, from antenna 12.

In step 162, an impedance value at the far end of antenna 12 is set equal to zero. With reference to Figure 1, switch 14 is closed. In this case the impedance value at the far end of antenna 12 is equal to zero

and antenna 12 represents a half wavelength loop. The same results can be achieved by using a specified impedance unit instead of switch 14. With reference to Figures 2 and 3, impedance unit 54, having impedance Z, is connected between the far end of antenna 12 and the ground. As was described above, the value of the impedance Z at the high frequency $2F_0$ is equal to zero.

In step 164, system 10 conducts communication. With reference to Figure 1, system 10 conducts communication in the high-frequency band. Depending on operation mode, switch 20 couples either transmitter 28 or receiver 30 with antenna 12 via switch 16.

Reference is now made to Figure 11, which is a schematic illustration of a method for operating communication multi-band system 100 of Figure 4, operative in accordance with another preferred embodiment of the present invention.

In step 170 an operation frequency band is selected. With reference to Figure 4, system 100 receives information regarding active frequency band and selects a mode of operation. In the case of low-frequency mode of operation system 100 proceeds to step 172 and in the case of high-frequency mode of operation system 100 proceeds to step 174.

In step 172, a far end of antenna 102 is coupled to a high-frequency unit filter. With reference to Figure 4, switch 110 couples the far end of antenna 102 to filter 122, via phase shifter 106.

In step 176, an impedance value at the input of the high-frequency phase shifter is set equal to infinity. With reference to Figure 4, phase shifter 106 is tuned in such a way that the impedance value at its input (connected to antenna 102) is equal to infinity. This is achieved by a special design of phase shifter 106. Any conventional type of phase shifters can be used, such as transmission lines of a corresponding length, for example. When the impedance value at the input of the phase shifter 106 is equal to infinity, then antenna 102 operates as an open quarter wavelength monopole.

In step 180, system 100 conducts communication. With reference to Figure 4, system 100 conducts communication in the low-frequency band. Depending on operation mode, switch 108 couples either transmitter 116 or receiver 114 with antenna 12 via switch 108 and phase shifter 104.

In step 174, a far end of antenna 102 is coupled to a low-frequency unit filter. With reference to Figure 4, switch 108 couples the far end of antenna 102 to filter 112, via phase shifter 104.

In step 178, an impedance value at the input of the low-frequency phase shifter is set equal to zero. With reference to Figure 4,

phase shifter 104 is tuned in such a way that the impedance value at its input (connected to antenna 102) is equal to zero. This is achieved by a special design of phase shifter 104. Any conventional type of phase shifters can be used, such as transmission lines of a corresponding length, for example. When the impedance value at the input of the phase shifter 104 is equal to zero, then antenna 102 operates as a half wavelength loop.

In step 180, system 100 conducts communication. With reference to Figure 4, system 100 conducts communication in the high-frequency band. Depending on operation mode, switch 110 couples either transmitter 118 or receiver 120 with antenna 12 via switch 110 and phase shifter 106.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

## CLAIMS

1. Antenna comprising:

   a flexible dielectric sheet; and

   at least one conductive pattern,

   said at least one conductive pattern being imprinted onto said flexible dielectric sheet.

2. The antenna according to claim 1, wherein at least one of said at least one conductive pattern includes a horizontal layout portion.

3. The antenna according to claim 1, wherein at least one of said at least one conductive pattern includes a vertical layout portion.

4. The antenna according to claim 1, wherein each said at least one conductive pattern includes at least two leads.

5. The antenna according to claim 4, wherein for each said at least one conductive pattern having more than two leads, is operative to a plurality of RF modes, each said RF modes being selected by coupling a transceiver to a respective pair combination of said more than two leads.

6. The antenna according to claim 1, wherein each said flexible dielectric sheet had the general shape of a circular section.

7. The antenna according to claim 1, wherein each said flexible dielectric sheet had the general shape of a rectangle.

8. The antenna according to claim 1, further comprising at least one electronic component, coupled to at least one of said at least one conductive pattern and attached to said flexible dielectric sheet.

9. The antenna according to claim 8, wherein said at least one electronic component is selected from the list consisting of:

a resistor;

a capacitor;

a coil;

a resonator;

an electromechanical unit; and

a semiconductor unit.

10. The antenna according to claim 1, further comprising a switch, coupled between at least a lead of at least one of said conductive patterns and the ground, wherein another lead of said specific at least

one of said conductive patterns is connected to a multiple mode transceiver.

11. The antenna according to claim 10, wherein said switch comprises a frequency dependent impedance unit,

wherein said frequency dependent impedance unit has a minimal impedance at a first frequency, respective of one mode of said multiple mode transceiver, and

wherein said frequency dependent impedance unit has a maximal impedance at a second frequency, respective of another mode of said multiple mode transceiver.

12. The antenna according to claim 11, wherein said maximal impedance is approximately infinity.

13. The antenna according to claim 11, wherein said minimal impedance is approximately zero.

14. The antenna according to claim 1, further comprising a rigid core, said flexible dielectric sheet being wrapped around a portion of said core.

15. The antenna according to claim 14, further comprising an elastic coating, covering at least a portion of the structure formed by said rigid core and said flexible dielectric sheet.

16. The antenna according to claim 14, wherein said core is generally shaped as a cylinder.

17. The antenna according to claim 14, wherein said core is generally shaped as a cone.

18. The antenna according to claim 1, further comprising:

a first phase shift unit, coupled between one lead of a selected one of said at least one conductive pattern and a first mode transceiver; and

a first phase shift unit, coupled between another lead of said selected one of said at least one conductive pattern and a second mode transceiver,

wherein the combination of said first phase shift unit and said first mode transceiver produces a maximal impedance value towards said selected one of said at least one conductive pattern, and

wherein the combination of said second phase shift unit and said second first mode transceiver produces a minimal impedance value towards said selected one of said at least one conductive pattern.

19. Frequency dependent antenna switch system for controlling the operation of an antenna, the antenna being coupled to a multi band transceiver, the switch system comprising a switch, coupled between an antenna and the ground

wherein said frequency dependent antenna switch is set to an open mode at a first frequency, respective of a first band of said multi band transceiver, and

wherein said frequency dependent antenna switch is set to a closed open mode at a second frequency, respective of a second band of said multi band transceiver.

20. The antenna switch system according to claim 19, wherein said open mode is characterized by a maximal impedance, and wherein said closed mode is characterized by a minimal impedance.

21. The antenna switch system according to claim 19, further comprising a band switch, coupled between said antenna and said multi band

transceiver, for switching between at least two bands, provided by said multi band transceiver.

22. The antenna switch system according to claim 19, further comprising a band switch, coupled between said antenna and said multi band transceiver,

wherein said band switch connects said antenna to at least two different band elements, each relating to a different band, at least one of said band elements being a receiver.

23. The antenna switch system according to claim 19, further comprising and antenna, said antenna comprising:

a flexible dielectric sheet; and

at least one conductive pattern,

said at least one conductive pattern being imprinted onto said sheet.

24. The antenna switch system according to claim 23, wherein at least one of said at least one conductive pattern includes a horizontal layout portion.

25. The antenna switch system according to claim 23, wherein at least one of said at least one conductive pattern includes a vertical layout portion.

26. The antenna switch system according to claim 23, wherein each said at least one conductive pattern includes at least two leads.

27. The antenna switch system according to claim 26, wherein for each said at least one conductive pattern having more than two leads, is operative to a plurality of RF modes, each said RF modes being selected by coupling a transceiver to a respective pair combination of said more than two leads.

28. The antenna switch system according to claim 23, wherein each said flexible dielectric sheet had the general shape of a circular section.

29. The antenna switch system according to claim 23, wherein each said flexible dielectric sheet had the general shape of a rectangle.

30. The antenna according to claim 23, further comprising at least one electronic component, coupled to at least one of said at least one conductive pattern and attached to said flexible dielectric sheet.

31. The antenna switch system according to claim 30, wherein said at least one electronic component is selected from the list consisting of:

a resistor;

a capacitor;

a coil;

a resonator;

an electromechanical unit; and

a semiconductor unit.

32. The antenna according to claim 20, wherein said maximal impedance is approximately infinity.

33. The antenna according to claim 20, wherein said minimal impedance is approximately zero.

34. The antenna according to claim 23, further comprising a rigid core, said flexible dielectric sheet being wrapped around a portion of said core.

35. The antenna according to claim 34, further comprising an elastic coating, covering at least a portion of the structure formed by said rigid core and said flexible dielectric sheet.

36. The antenna according to claim 34, wherein said core is generally shaped as a cylinder.

37. The antenna according to claim 34, wherein said core is generally shaped as a cone.

38. Antenna switching system comprising:

a first phase shift unit, coupled between a first end of an antenna and a first transceiver; and

a second phase shift unit, coupled between a second end of said antenna and a second transceiver.

39. The antenna switching system according to claim 38, wherein said first phase shift unit shifts the impedance of said first transceiver, at a first band, so as to induce maximal impedance towards said antenna, and

wherein said second phase shift unit shifts the impedance of said second transceiver, at a second band, so as to induce minimal impedance towards said antenna

40. The antenna switch system according to claim 38, further comprising and antenna, said antenna comprising:

a flexible dielectric sheet; and

at least one conductive pattern,

said at least one conductive pattern being imprinted onto said sheet.

41. The antenna switch system according to claim 40, wherein at least one of said at least one conductive pattern includes a horizontal layout portion.

42. The antenna switch system according to claim 40, wherein at least one of said at least one conductive pattern includes a vertical layout portion.

43. The antenna switch system according to claim 40, wherein each said at least one conductive pattern includes at least two leads.

44. The antenna switch system according to claim 43, wherein for each said at least one conductive pattern having more than two leads, is operative to a plurality of RF modes, each said RF modes being selected by coupling a transceiver to a respective pair combination of said more than two leads.

45. The antenna switch system according to claim 40, wherein each said flexible dielectric sheet had the general shape of a circular section.

46. The antenna switch system according to claim 40, wherein each said flexible dielectric sheet had the general shape of a rectangle.

47. The antenna according to claim 40, further comprising at least one electronic component, coupled to at least one of said at least one conductive pattern and attached to said flexible dielectric sheet.

48. The antenna according to claim 39, wherein said maximal impedance is approximately infinity.

49. The antenna according to claim 39, wherein said minimal impedance is approximately zero.

50. The antenna switch system according to claim 47, wherein said at least one electronic component is selected from the list consisting of:

a resistor;

a capacitor;

a coil;

a resonator;

an electromechanical unit; and

a semiconductor unit.

51. The antenna according to claim 40, further comprising a rigid core, said flexible dielectric sheet being wrapped around a portion of said core.

52. The antenna according to claim 51, further comprising an elastic coating, covering at least a portion of the structure formed by said rigid core and said flexible dielectric sheet.

53. The antenna according to claim 51, wherein said core is generally shaped as a cylinder.

54. The antenna according to claim 51, wherein said core is generally shaped as a cone.

55. Method for operating a dual section transceiver and an antenna, coupled there between, the antenna being further coupled to the ground via a variable impedance connection, each said transceiver sections being associated with a respective frequency band, each said transceiver sections including at least one of a transmitter and a receiver, the method comprising the steps of:

coupling said antenna to the transceiver section associated with a selected one of said frequency bands;

disconnecting said antenna from the transceiver section associated with the non selected frequency band;

setting said variable impedance connection to a high impedance value, when said selected frequency band is low; and

setting said variable impedance connection to a low impedance value, when said selected frequency band is high.

56. The method according to claim 55, further comprising a preliminary step of selecting one of said frequency bands.

57. The method according to claim 55, further comprising a final step of conducting communication at said selected frequency band.

58. The antenna according to claim 55, wherein said high impedance value is approximately infinity.

59. The antenna according to claim 55, wherein said low impedance value is approximately zero.

60. Method for operating two transceivers and an antenna, one of said transceivers being a low band transceiver, the other of said transceivers being a high band transceiver, the low band transceiver being coupled to a first end of the antenna via a first phase shift connection, the high band transceiver being coupled to a second end of the antenna via a second phase shift connection, each said transceiver sections including a transmitter and a receiver, the method comprising the steps of:

coupling said antenna to the receiver of a non selected one of said transceivers;

setting said first phase shift connection to a predetermined value thereby inducing low impedance from said low band transceiver to said antenna, when selecting said high band transceiver; and

setting said second phase shift connection to a predetermined value thereby inducing high impedance from said high band

transceiver to said antenna, when selecting said low band transceiver.

61. The method according to claim 60, further comprising a preliminary step of selecting one of said transceivers.

62. The method according to claim 60, further comprising a final step of conducting communication at frequency band respective of said selected transceiver.

63. The antenna according to claim 60, wherein said high impedance is approximately infinity.

64. The antenna according to claim 60, wherein said low impedance is approximately zero.

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| **Application No:** | GB 0009686.7 | **Examiner:** | Rachel Foxon |
| **Claims searched:** | 1-18 | **Date of search:** | 25 October 2000 |

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# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H1Q (QJC) (QKA) (QKN) (QHC) (QHX)

Int Cl (Ed.7): H01Q 1/08, 1/12, 1/38, 9/04, 9/06

Other: Online: WPI, EPODOC, JAPIO

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| X | GB 2293274 | Motorola Inc (see esp. Pg 6 line 11-16 pg 8 lines 20-22) | 1-4,7 |
| X | EP 0821406 | Checkpoint Systems (see esp. col 4 lines 26-33, col 8 lines 16-21 and 53-55) | 1-3,7-9 |
| X,E | WO 00/30208 | Scordilis (see esp pg 7 lines 19-23, pg 9 lines 12-17, pg 11 lines 11-13, figs 2b,5) | 1-4,6-7,14,15,17 |
| X | US 5838285 | Motorola Inc (see esp col 2 lines 46-50, fig 2) | 1-4,7 |
| X | US 5198831 | 501 Pronav International (see esp col 3 lines 21-25, figs 6,12) | 1-4,6-9 |
| X | US 3971125 | Raytheon (see esp col 2 lines 27-30, 53-63, fig 6) | 1-4, 6,14,16 |

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